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Music Influences Ratings of the Affect of Visual Stimuli

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Abstract

This review provides an overview of recent studies that have examined how music influences the judgment of emotional stimuli, including affective pictures and film clips. The relevant findings are incorporated within a broader theory of music and emotion, and suggestions for future research are offered.

Music is important in our daily lives, and one of its primary uses by listeners is the active regulation of one's mood. Despite this widespread use as a regulator of mood and its general pervasiveness in our society, the number of studies investigating the issue of whether, and how, music affects mood and emotional behaviour is limited however. Experiments investigating the effects of music have generally focused on how the emotional valence of background music impacts how affective pictures and/or film clips are evaluated. These studies have demonstrated strong effects of music on the emotional judgment of such stimuli. Most studies have reported concurrent background music to enhance the emotional valence when music and pictures are emotionally congruent. On the other hand, when music and pictures are emotionally incongruent, the ratings of the affect of the pictures will in- or decrease depending on the emotional valence of the background music. These results appear to be consistent in studies investigating the effects of (background) music.

Keywords: music, emotion, cross-modal emotion perception, affective pictures

Music plays an important part in many people's lives. This is the case for all of the world's cultures, and has been so since the early development of mankind as a social species (e.g. Cross, 2003; Dissanayake, 2006, 2008). Many of our daily activities are accompanied by music in both social and work settings. In fact, most of the time music is listened to, it is heard as background during other activities

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(Juslin & Laukka, 2004; Sloboda, O'Neill, & Ivaldi, 2001). With the development of mobile sound carriers since the late 1970s from walkmans to mp3-players and smart phones today, it is now possible to listen to music at any moment of the day, and music is therefore more salient in our daily lives than ever before.

It has been established that music can have substantial effects on mood and behaviour (e.g. Saarikallio, 2010), in consumer behaviour (see Garlin & Owen, 2005 for a review), and in music therapy (see Aldridge, 2004 for a review). However, despite music's many uses and its pervasiveness in our society, there is no consensus as to its origins and evolution. While some scholars view music as an evolutionary by-product of language (e.g. Pinker, 1997), others point out the important roles music has played throughout the ages in our history and still plays in our current society, particularly music as an instrument to promote social cohesion (see Cross, 2003; Huron, 2003 for reviews). It was recently established that newborn infants already possess the ability to recognize the beat in music (Winkler, Haden, Ladinig, Sziller, & Honing, 2009) and this skill may be crucial to the further development of music in our species (Honing, 2012). The ability to recognize beat at birth supports the idea that the competence to perceive and enjoy music is innate to our species (see Trehub, 2001). It is important to realize that musical behaviour encompasses much more than the predominantly western view of professional musicians and performers i.e., that making music requires special talents. In a broader perspective, musical behaviour involves the ability to recognize and sing along with tunes, to enjoy melodies and to respond rhythmically by, for instance, dancing or clapping along (e.g. Dissanayake, 2008).

Musical experiences are often described as very rewarding in nature, and the ability of music to evoke emotion in its listeners may contribute greatly to its appeal (Zentner, Grandjean, & Scherer, 2008). In fact, one of the most important reasons for listening to music is its ability to elicit strong emotion in listeners (Juslin & Laukka, 2004; Sloboda & O'Neill, 2001). The areas of the brain that are activated by emotional music are similar to those associated with such strongly rewarding activities and stimuli as games, drugs, food and sex (e.g., Blood & Zatorre, 2001; Brown, Martinez, & Parsons, 2004; Mitterschiffthaler, Fu, Dalton, Andrew, & Williams, 2007; Salimpoor, Benovoy, Longo, Cooperstock, & Zatorre, 2011). A recent study by Molet, Billiet, and Bargo (2013) suggested that this ability to enjoy music may be unique to humans.

Despite music's widespread use as a regulator of mood (e.g. Saarikallio, 2010), and as a source of emotion in many areas of life, there is still discussion as to how and why music elicits emotion in listeners (see Sloboda & Juslin, 2001; Zentner et al., 2008), and even if emotion in music is not only recognized rather than actually felt by listeners (Scherer & Zentner, 2001). This problem may in part be due to the

ongoing discussion of what an emotion is (Sloboda & Juslin, 2001) and due to the fact that current theories of emotion may not be ideally suited to describe the emotions expressed or induced by aesthetics (Frijda & Sundararajan, 2007) and particularly music (Dissanayake, 2006; Zentner et al., 2008).

The dimensional model of emotion is currently one of the dominant models (Russell, 1980), and it is also widely used in the study of musical emotions. This model suggests two orthogonal dimensions of emotion, valence and arousal, which together form four quadrants of affective space. Categorical descriptions of emotion are often used in combination with the dimensional model to describe affect, for instance, happy and excited correspond to high valence and high arousal, while depression and sadness are examples of emotional states low in both valence and arousal. There are, however, some limitations concerning the dimensional model when it comes to studying music, for instance, sadness and depression take up similar positions within affective space, but are qualitatively different emotions (see Juslin & Laukka, 2004). In addition, the dimensional model may not be sufficiently sensitive to differentiate between the nuances of musical emotion (see Juslin & Laukka, 2004; Zentner et al., 2008). More precisely, although it may be able to differentiate between basic perceived emotions, it is probably unfit to detect subtle differences within those emotions. Not all emotions are perceived or felt when listening to music, and there is still discussion on what emotions can be expressed or induced. Jealousy is an example of an emotion that is hardly ever experienced through music. Juslin and Laukka (2004) established that the emotions of happiness, sadness, tenderness, anger, pride and fear are the most often expressed by music, while being moved, curiousness, amazement, enchantment, nostalgia, solemness, happiness, tenderness, and sadness are the emotions commonly induced by music. Zentner et al. (2008) listed the following nine emotions as being generally induced by music, some of which overlap with those of Juslin and Laukka (2004): wonder, transcendence, tenderness, nostalgia, peacefulness, power, joyful activation, tension and sadness.

Despite their findings and suggestions for a more refined labelling of musical emotions, Zentner et al. (2008) note that the use of categorical labels of emotion and the dimensional model may suffice when describing perceived affect in music. In turn, happy, sad and fearful emotion in western music can be recognized cross-culturally (Fritz et al., 2009). Furthermore, affect in music can be recognized in very short excerpts. There is even no difference in the accuracy of judgment between excerpts as short as 300ms and longer passages (Bigand, Vieillard, Madurell, Marozeau, & Dacquet, 2005; Krumhansl, 2010). Music is therefore a powerful elicitor of emotion, and pervasive in our daily lives in many situations. The goal of this contribution is to discuss the research on how music influences

ratings of affect of visual stimuli, mainly emotional pictures, and to place these findings in a broader framework of emotion.

Effects of Music on the Perception of Affective Pictures

The number of studies investigating the issue of whether, and how, music affects perception of emotion is limited. This is even more surprising, since the practice of studying the combined presentation and integration of auditory and visual information has been going on for several decades (De Gelder & Vroomen, 2000; McGurk & MacDonald, 1976). In addition, it has been repeatedly demonstrated that an emotional stimulus, including music, can effectively influence one's perception, even when this percept is not emotional in nature (Jolij & Meurs, 2011; Zadra & Clore, 2011). Studies investigating affective integration from different modalities have mainly focused on combining emotionally spoken words with facial expressions (e.g., De Gelder & Vroomen, 2000). The past decade has witnessed an increase in studies using music as the source of emotion in the auditory domain. An overview follows of the experiments that have explored the effects of music on the evaluation of pictures (Table 1 provides a schematic overview of the studies used in this review). Studies are discussed in terms of their methodology, findings and conclusions. We made a distinction between experiments presenting music at the same time as the visual stimulus, and studies that use music as an emotional prime. Another recurring methodological theme is congruence/incongruence, i.e., if the emotions of the visual and auditory stimulus match or do not match each other. Unless specifically stated otherwise, all music discussed in this review is instrumental without vocals or text.

Music Presented while Rating Pictures

Baumgartner, Esslen, and Jäncke (2005) established that music can enhance the experienced emotion of affective pictures. These investigators used musical stimuli of 70s in length representing fear, sadness and happiness, with visual stimuli selected from the same discrete categories of the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1995). All pictures contained humans or human faces. These investigators recorded the EEG while participants were asked to rate the fear, sadness and happiness of each picture and participants' involvement, on 5-point Likert-scales. In addition, heart rate, skin conductance, respiration and skin temperature was recorded. A mood induction procedure was used in which participants were instructed to place themselves in the same mood as represented by the emotional stimuli (both music and pictures), and all stimuli were rated in separate music and picture conditions as well as a condition in which music

Table 1. *Schematic Overview of the Studies Reviewed*

Authors	Stimuli and Design	Findings	Conclusions
(1) Baumgartner et al., 2005	Participants: 24 women Stimuli: 3 pieces of classical music (happy, sad, fearful) and 48 pictures in the same categories. Measures: ratings of happiness, sadness, fearfulness and involvement on 5-point scales. EEG-recordings and additional psychophysiological measurements. Design: congruent pictures (shown for 4.375s) were rated while listening to music (70s). Music and picture control conditions were measured.	Combined congruent conditions increased experienced affect as well as involvement compared to music or pictures alone. This is supported by EEG Alpha-power density.	Music enhances the emotional experience of affective pictures.
(2) Baumgartner et al., 2006	Participants: 9 women Stimuli: 3 pieces of classical music (happy, sad, fearful) and 54 pictures in the same categories. Measures: ratings of happiness, sadness, fearfulness and involvement on 5-point scales. fMRI-scans were made during presentation of stimuli. Design: pictures (shown for 4.8s) were rated alone or in combination with congruent music (presented for 44s).	Combined congruent conditions increased experienced affect as well as involvement compared to pictures alone. fMRI-scans showed increased activation in areas of the brain associated with emotion processing in the combined condition, while pictures alone mainly activated areas of the brain associated with cognitive evaluations.	Music enhances the emotional experience of affective pictures. The combined congruent presentation of music and affective pictures may automatically evoke strong emotions, while pictures alone may trigger a cognitive approach towards the perception of emotion.

Authors	Stimuli and Design	Findings	Conclusions
(3) Jeong et al., 2010	Participants: 15 (10 women) who took part in the fMRI, and 11 of them completed the behavioural section. Stimuli: happy and sad faces, happy and sad music Measures: fMRI and valence (scale -7 to +7) Design: combined congruent and incongruent presentation of music (30s) and faces (3s) and only music/picture control conditions.	Happy music made happy faces happier and sad faces less sad, and the opposite was found for sad music. BOLD-levels as measured by fMRI revealed increased activation in the superior temporal gyrus when music and picture were congruent. Incongruent stimuli yielded greater activation in the fusiform gyrus.	Valence ratings of pictures are directed towards the affect of concurrently presented music. Congruent music and pictures increase activity in auditory regions of the brain, while incongruent pairs may cause an increase in regions of the brain associated with facial processing.
(4) Hanser et al., in press	Participants: 366 (209 women) Stimuli: 24 crying, angry, yawning and smiling faces and sad, angry, calm and happy music Measures: kindness, pleasantness and attractiveness on 9-point scales Designed: combined congruent and incongruent combination of music (+/- 120s) and faces (2s) and only music/picture control conditions	Calm and sad music made crying faces kinder and more pleasant. Calm music made crying faces more attractive. Calm music made angry faces less kind, pleasant and attractive. Sad and angry music made angry faces less pleasant.	Calm and sad background music may be helpful in boosting social bonding and empathy when people are in tears.

Authors	Stimuli and Design	Findings	Conclusions
(5) Logeswaran & Bhattacharya, 2009	This study consisted of two experiments: 1) Participants: 30 (15 women) Stimuli: 90 happy, sad and neutral faces, 90 pieces of classical music 15s in length Measures: valence on a scale of 1 to 7 Design: Pictures were rated in congruent and incongruent conditions after being primed with music. 2) Participants: 16 (8 women) Stimuli: 120 happy, sad and neutral pictures 120 pieces of classical music 15s in length Measures: ERPs Design: Pictures were primed with congruent and incongruent music. Participants pushed a button when a female was seen.	More positive ratings were obtained when happy music primed a picture, while more negative judgments were made when pictures were primed with sad music. ERP-data revealed early components.	Musical primes in- or decrease valence ratings of facial expressions. This effect is largest for neutral faces. ERP-data suggests that integration of visual and auditory stimuli occurs automatically in the early stages of information processing.
(6) Marin at al., 2012	This study consisted of three experiments. Experiments 2 and 3 were the same. 1) Participants: 32 men and women Stimuli: 120 IAPS pictures from all quadrants of affective space and 120 pieces of music (average length 32s) in similar categories Measures: valence and arousal ratings on a 7-point scale. Design: Pictures were primed by congruent and incongruent music. 2) Participants 40 (20 women) 3) Participants: 14 Stimuli: 20 pictures presented four times and 80 pieces of music (both selected from study 1) Measures: Valence and arousal on a 7-point scale.	Men reported higher levels of arousal than women, and more musical training was related to reports of higher arousal to unpleasant stimuli. No effect of music was found on ratings of valence, though unpleasant musical stimuli led to higher ratings of arousal in visual targets. Ratings of arousal were influenced by musical primes, and the shift in arousal ratings reflected the emotional category of the musical stimulus.	Cross-modal transfer of arousal is possible, and may differ from the transfer of valence depending on the visual stimulus.

and pictures were presented together. Self-reported ratings of happiness, sadness, fear and involvement demonstrated an enhanced effect of music on the judgments made by participants on all three picture categories in the combined condition. Psychophysiological findings and alpha-power-density as measured by EEG in particular, revealed increased effects for the combined music and picture conditions compared to pictures or music alone, suggesting music enhanced the experience of the affective pictures.

This finding that music enhances the experienced emotion induced by affective pictures was replicated by Baumgartner, Lutz, Schmidt, and Jäncke (2006). Sad, happy and fearful pictures were presented to participants while they were listening to congruent sad, happy and fearful music excerpts of 44s in length or in a condition with pictures alone. Participants were again instructed to try to feel the depicted moods of both music and pictures. Compared to a condition with just pictures, affect was enhanced in a picture and music condition. Musical stimuli were the same as those used in Baumgartner et al. (2005), and pictures originated from the IAPS or were collected by the authors (Lang et al., 1995) and contained humans or human faces. Self-reported measures of discrete emotions demonstrated an enhanced emotional experience and increased involvement in the combined music and picture condition compared to pictures alone. fMRI revealed increased activation in areas of the brain associated with emotion processing for the combined condition, most importantly in the fusiform gyrus (FG) and areas involved in auditory processing like the superior temporal gyrus (STG). In the picture only condition, increased activation in areas of the brain associated with cognitive processes including the dorsolateral prefrontal cortex was evident. However, no fMRI-scans were made for a music only condition, so there was no certainty as to whether the findings could be attributed to music alone or to the combination with pictures. The investigators concluded that the combined congruent presentation of emotional auditory and visual stimuli automatically arouses strong feelings and emotional experiences in listeners, whereas the picture only condition leads to a more cognitive evaluation of the percept.

Jeong et al. (2011) also explored self-ratings of valence and neurophysiological (as measured by fMRI) effects of both congruent and incongruent happy and sad music on happy and sad facial expressions. Participants made judgments on a scale ranging from -7 (saddest) to +7 (happiest) for music, picture and combined conditions. Their results revealed a significant effect of music on ratings, demonstrating that judgments were more positive with happy music than with sad music and vice versa. In agreement with Baumgartner et al. (2006), this study also demonstrated increased activation in the fusiform gyrus (FG) and the superior temporal gyrus (STG), while activation of the FG was found to be

the greatest for incongruent conditions. The authors suggested that during incongruent conditions there is a shift to the regions involved with processing facial information, while the congruent conditions result in increased activation in areas relating to auditory stimuli, i.e. music.

The modulating effect of music on the rating of facial expressions is not limited to measurements of valence or arousal. A recent study demonstrated music to affect empathy-related judgments for pictures of individuals that were either crying or angry (Hanser, Mark, Zijlstra, & Vingerhoets, in press). In this study, participants rated crying, angry, yawning and smiling facial expressions on a 9-point scale on dimensions of kindness, pleasantness and attractiveness, while simultaneously listening to sad, calm, angry and happy music. When criers were rated with sad and calm music, they were judged as being kinder and more pleasant than with no music, while calm music made angry people look less kind, pleasant and attractive. These investigators suggest that their findings may help explain why sad or soothing music is used during rituals of loss. The effect of calm music on the rating of angry faces emphasizes the importance of investigating non-congruent music and picture combinations. No effect of music was reported on ratings of smiling and yawning pictures.

Music as the Emotional Prime

The four previously discussed experiments all presented music simultaneously with the visual stimuli. Music has, however, also been used as an emotional prime played before a series of affective pictures are presented. Logeswaran and Bhattacharya (2009) gathered valence ratings as well as ERP-data on how happy and sad music influenced happy, sad and neutral faces in both congruent and incongruent combinations. Participants made judgments on a 7-point scale rating the perceived valence of the facial stimuli, and were instructed to try and feel the emotion of the musical stimulus. Unfortunately, the valence of the musical stimuli (happy, sad) was not measured in this experiment. Results showed that when happy music preceded a happy/sad picture, this picture was rated as more positive than with sad music and vice versa. This effect was largest when judging neutral pictures. The observation that neutral stimuli are more affected by the emotion of a consecutive stimulus was established previously with voices and faces (Massaro & Egan, 1996), and with emotional words and faces (De Gelder & Vroomen, 2000). Explicit emotional judgments were not measured during the ERP-part of their experiment, but instead, participants had to respond when the face was that of a woman. ERP-data revealed effects in the early stages of information processing which the authors attribute to an early integration of the auditory and visual stimuli.

Chen, Yuan, Huang, Chen, and Hong (2008) also reported an early, possibly subconscious, integration of happy and sad affective pictures with happy and sad classical music as emotional primes, while Spreckelmeyer, Kutas, Urbach, Altenmüller, and Münte (2006) reported such early ERP-components for IAPS-pictures that were combined with voices.

Even though affective space consists of the two dimensions valence and arousal (Russell, 1980), the latter has largely been neglected in the current line of cross-modal research with music, despite findings that suggest that the rewarding nature of music is directly linked to the arousal dimension (Salimpoor et al., 2011). Marin, Gingras, and Bhattacharya (2012) explored effects of music on ratings of arousal and valence of IAPS-pictures (Lang, Bradley, & Cuthbert, 2005), with music as an emotional prime. In addition, this is the first study to date to explore all four quadrants of affective space instead of just happiness and sadness. These investigators carried out three experiments in which participants judged musical excerpts (romantic piano music) and pictures on 7-point Likert scales. Experiment I served as careful pretesting of stimuli while experiments II and III explored effects of music on the IAPS-pictures. The authors reported effects for arousal but, surprisingly, not for emotional valence. Shifts in arousal reflected the emotional quality of the music, i.e., high arousing music increased perceived arousal of pictures, while less arousing music decreased arousal ratings. In addition, while pleasantness ratings were not significantly affected, unpleasant music led to higher arousal ratings of visual stimuli. The lack of effect for emotional valence is attributed to the selection of musical stimuli that varied less in valence than in arousal, the IAPS-pictures that were visually complex, or the specific combination of the music and the visual stimuli. In combination with previous research (e.g., Logeswaran & Bhattacharya, 2009), the authors put forth the highly interesting hypothesis that it may be easier for music to affect the valence of facial expressions compared to complex IAPS-pictures due to the highly social nature of both music and these expressions. The authors further make a strong case for careful monitoring and (pre-)testing of stimulus materials due to possible effects of gender and musical expertise and familiarity or effects that are specifically related to the stimulus material. They reported higher levels for arousal in unpleasant musical stimuli when this was coupled with formal musical training. Men also provided higher ratings of arousal than women in this study.

Simultaneous Playback of Music Versus Music as a Prime

To summarize, two global strands of research in terms of effects of music on affective pictures can be discerned. Firstly, studies that explore the effects of

concurrently played (background) music on the judgments of emotional pictures (Baumgartner et al., 2005, 2006; Jeong et al., 2011), and secondly, experiments that use music as an affective prime before subsequently presented images (Logeswaran & Bhattacharya, 2009; Marin et al., 2012). As discussed by Marin et al. (2012), both of these methods have different theoretical backgrounds and differ in their presentation of stimuli. The concurrent exposure to visual and auditory stimuli may in fact be considered as one integral stimulus, while the priming experiments present two subsequent stimuli. Effects may thus be explained by theories of cross-modal integration on the one hand, and evaluative priming on the other (Marin et al., 2012). Studies that use music as a prime also generally have a short presentation of the auditory stimulus (e.g. Chen et al., 2008; Logeswaran & Bhattacharya, 2009), while concurrently presented auditory stimuli are usually presented for a longer time-interval (e.g., Baumgartner et al., 2005, 2006). In the latter studies, mood induction may be more likely than the much shorter induction of emotion that is presumed to underlie the effects of priming (Marin et al., 2012; Scherer, 2004; Scherer & Zentner, 2001). We could find only two studies in which the presentation time of music for priming (Marin et al., 2012) and concurrent presentation (Jeong et al., 2011) was close to similar. Despite these theoretical and practical differences, there is some overlap between findings meriting comparisons between studies using either of these two methods. Furthermore, both of these methods occur in real life situations. An interesting and valuable experiment would thus be to combine these two strands of research into a single study or a series of experiments using the same musical and visual stimuli (comprised of both IAPS-pictures and facial expressions), matching rating scales for both methods, and a comparison of presentation times in order to draw conclusions on what these methods have in common and what disparities exist in both self-reported ratings as well as psychophysiological data. The results could provide helpful information on whether one or the other or both methods could be used in a practical setting.

Can the Perceived Emotion in Music be Affected by Visual Stimuli as Well?

A logical assumption that follows from the consistent finding of effects of music on the perception of emotion in another modality is that emotional stimuli in other modalities will also have an effect on the judgments made of the emotional properties of the music that is heard. This question remained unaddressed until recently. Spreckelmeyer et al. (2006) demonstrated that happy voices are rated as happier when concurrently presented with happy IAPS-pictures, and vice versa for sad pictures. Kamiyama, Abla, Iwanaga, and Okanoya (2013) investigated the effects of happy and sad facial expressions on happy and sad musical excerpts

using an affective priming paradigm with visual stimuli preceding the musical stimulus. ERPs were recorded while participants judged the picture and music congruence/incongruence in terms of valence. Study participants made faster judgments in congruent conditions than when music and picture were a mismatch. The ERP-data suggested a facilitation of integration of congruent music and picture combinations, while data on incongruent pairs suggested an inhibition of integration. The authors also compared non-musicians to participants with formal musical training, but found no differences between both these groups. While stimuli were pretested in order to ascertain that they induced the assumed emotions, Kamiyama et al. (2013) included no ratings of how sad/happy the pieces of music were after priming. This is unfortunate because it would have been helpful in determining if the music affect is enhanced/diminished by a congruent/incongruent visual prime.

Maes and Leman (2013) demonstrated that it is possible to alter children's perception of emotion in emotionally ambiguous pieces of music by teaching them happy/sad dance moves to these pieces of music. When taught happy (sad) moves, children perceived a piece of music as happier (sadder) than when not taught the dance, or when coupled with emotionally opposite dance moves. The authors have some reservations as to the possibility of the effect in adults, since more experienced listeners may have been conditioned to hear certain emotions in pieces of music via, for instance, the tempi. In addition, the possibility could not be ruled out that some of the effects were not only due to the children performing the conditioned dance moves themselves, but also were caused by observing others dancing and by the act of dancing as part of a group. While this study is different from the other experiments in that a form of emotional conditioning is present, it demonstrates that it is possible to alter the perceived emotion in a piece of music.

Taken together, these three studies suggest that emotions evoked by music are susceptible to the influence of emotional stimuli in other modalities. This leads to questions as to what kind of stimuli and which emotions will affect the perceived emotion in music. Will there be carry-over effects from a piece of music to a subsequently presented piece of music, and will all emotional categories of affective pictures influence judgments of music one is being exposed to?

Cross-modal Emotion Effects in Film

One of the main uses of music in film is to evoke emotion in viewers (e.g., Cohen, 2001). Despite the obvious overlap between the experience of film and studies of cross-modal emotion perception, there are some differences that make a direct comparison between these two fields of research difficult. First, studies of

cross-modal emotion perception have generally used static visual images (faces or complex affective photographs, such as IAPS-pictures) as opposed to moving film clips. Second, the movie clips are often established or assumed to be emotionally neutral; there is therefore no cross-modal interaction of emotion, but only the affect from the music (see Pavlović & Marković, 2011 for an exception). Nevertheless, several studies of film music and movie clips have yielded interesting results and insights, confirming music's affective power. Music has been demonstrated to provide film clips containing poor or neutral affect with an enhanced emotional experience (Eldar, Ganor, Admon, Bleich, & Hendler, 2007). Furthermore, music can be used as an affective prime both before and after a scene to influence a viewer's evaluations about a character's emotions and expected intentions (Tan, Spackman, & Bezdek, 2007). Finally, Hoeckner, Wyatt, Decety, and Nusbaum (2011) demonstrated that music modulated empathy-related judgements of film characters, with viewers rating characters as more likeable when watched with melodramatic background music than during thriller (tense) music. This study thus demonstrates that music contributes significantly to the experience of film, and it has yielded further evidence that it can dramatically alter one's perception of emotion. In addition, over a hundred years of film has provided us with many scenes and situations that warrant further analysis. For instance, viewers' responses to severe incongruence between film and music, as exemplified by very happy music accompanying extreme violence in Stanley Kubrick's *A Clockwork Orange* (1971), has, thus far, received little research attention. A recent study by Pavlović and Marković (2011) highlights the importance of investigating these incongruent pairings. These authors reported, among others, increased levels of disgust when 'trustful' music was paired with a disgusting film clip.

Summary, Implications, and Suggestions for Future Research

The research until now suggests strong emotional effects of music on the perception of affective pictures, facial expressions and film. Concurrently presented as well as primed congruent music both influence the perceived and experienced emotion as measured by self-ratings of affective pictures (e.g., IAPS), facial expressions (Baumgartner et al., 2005, 2006; Jeong et al., 2011; Logeswaran & Bhattacharya, 2009; Marin et al., 2012; Spreckelmeyer et al., 2006), and film clips (Eldar et al., 2007). In incongruent conditions the ratings are directed towards the emotional properties of the music. These effects become stronger when visual stimuli are more emotionally neutral or ambiguous. Self-reported ratings of enhanced affect are supported by psychophysiological measurements of Alpha-Power Density in EEGs (Baumgartner et al., 2005) and increased BOLD levels in

fMRI-studies (Baumgartner et al., 2006; Eldar et al., 2007; Jeong et al., 2011). Furthermore, the integration of visual and auditory emotional information appears to happen automatically and relatively fast after stimulus presentation as established via ERPs (Kamiyama et al., 2013; Logeswaran & Bhattacharya, 2009; Spreckelmeyer et al., 2006). Note that this priming effect is bi-directional, i.e., it has been demonstrated with music as a prime before faces (valence) and IAPS-pictures (arousal), and with music as the target of primed faces. Music thus not only influences ratings of pictures, but pictures can influence the rating of music as well. Some recent findings by Maes and Leman (2013) and Spreckelmeyer et al. (2006) suggest that emotions perceived in music may also be influenced by the exposure to emotional stimuli in other modalities, such as kinesthetic. Lastly, the effects of music are not limited to just measures of valence and arousal, but extend (in film) to measures of the personality of the character, motivation and empathy-related ratings (Hanser et al., in press; Hoeckner et al., 2011; Tan et al., 2007).

Results obtained in these studies may in part be understood in the light of music's communicative and social functions. Indeed, the observed enhancement of emotion and faster reaction times when visual and auditory stimuli are congruent can be explained as an emotional message becoming clearer with more information available from multimodal sources. There are various ways through which music can elicit emotion in listeners and these can all be active at the same time (see Huron, 2012; Scherer & Zentner, 2001). These include: (1) association/memory (music may have been associated with an emotional memory experienced in the past); (2) empathic responses (acoustic features in music may reflect emotional responses, for instance, certain sounds may be perceived as laughter and arouse happiness); (3) and cognitive evaluation (acoustic features are interpreted to have concrete meaning which in turn evokes emotion). Huron (2012) recently suggested a fourth mechanism based on ethological theories of emotion: (4) signalling. Ethological theory suggests that facial expressions and other manifestations of emotion are not necessarily intended to communicate what someone is feeling, but are actively used to evoke a response in observers. The suggestion of signalling is appealing since it emphasizes the social use of music and its effects on emotion perception, and may in part explain why certain rituals are so often accompanied by music (Dissanayake, 2006, 2008). Perhaps one of the best examples is the use of music during funeral rites (see also Huron, 2012 on grief).

Behaviour during rituals of loss is aimed at relief from grief and receiving empathy from others. Music has been demonstrated to modulate empathy-related measurements in film (Hoeckner et al., 2011) and may thus promote pro-social behaviour and bonding during these rituals. Like directors of films (e.g., Cohen, 2001; Hoeckner et al., 2011; Tan et al., 2007), individuals may thus actively shape

their own and others' responses to, and interpretation of their actions by others through the music they play. More research is needed to further explore the empathy enhancing properties of certain types of music.

In summary, consistency is found in the literature in terms of the overall effect music has on the rating of pictures. There are also differences between studies however, in particular with regard to effect-strength when rating IAPS-pictures (Baumgartner et al., 2005, 2006; Marin et al., 2012), rating scales, and different musical and visual stimuli. A systematic comparison using similar stimuli (e.g. IAPS-pictures and facial expressions), methods (concurrent presentation, priming), presentation times and rating-scales might yield helpful information to enable drawing clearer conclusions on how exactly music affects visual stimuli and if these effects differ, for instance, for faces and IAPS-pictures. Furthermore, Marin et al. (2012) emphasized that controlling and pre-testing both visual and musical stimuli is an important issue, since (null) findings may be specific to the nature of the stimuli or groups of stimuli used. The musical stimuli used so far in literature were mostly western classical music. However, within classical music, like in any genre, there is a wide variety in subgenres. Since effects may be specific to certain types of music, it is necessary to be specific and replication studies may be needed with different types of music.

While it may be helpful in the design of some experiments, it may be feasible not to specifically instruct participants to try to feel the emotions heard and displayed. Rather, it seems more ecologically valid not to give instructions that make participants attentive to the music, since it is most often heard in the background while being otherwise engaged. This may be especially true since it has been established that the auditory stimuli influence judgments even when subjects are specifically instructed not to attend to it (Van den Stock, Peretz, & De Gelder, 2009) and any effects of music thus happen either automatically or very early in the information processing hierarchy, as suggested by ERP-data in various experiments (Chen et al., 2008; Kamiyama et al., 2013; Logeswaran & Bhattacharya, 2009). Participant characteristics such as gender and musical education should be taken into account as well (see also Marin et al., 2012). Most of the studies have only used female participants (Baumgartner et al., 2005, 2006) or did not specifically look at gender differences (Jeong et al., 2011). The few experiments that have looked at this found differences in ratings of arousal between men and women, with higher levels of arousal reported by men (Marin et al., 2012). Furthermore, formal musical training may not affect the music's effects on emotion perception (Kamiyama et al., 2013), which suggests that recognition of emotion in music is a basic skill present in everyone, but formal training may play a role in identifying emotions in more complex pieces of music (see Marin et al., 2012 for a discussion).

Personality may be another variable that is worth looking at in future experimentation.

Research into cross-modal emotion perception may benefit general theories of emotion, and may help gain a better understanding of what musical emotions exactly are, and how they are, or can be induced. Pieces of music particularly suited to induce music-specific emotions as suggested by Zentner et al. (2008) should be further investigated. In addition, it may be helpful to explore each quadrant of affective space separately and to attempt to identify musical stimuli that reflect each of the emotions (for example, sad and depressed) that are assumed to lie close together, but that actually differ subtly in nature.

Practical Relevance

Afflictions and disorders in which emotion recognition is impaired or otherwise distorted may benefit greatly from the finding that music enhances affect, while treatments involving desensitisation may find help in music's ability to decrease perceived and/or experienced fearfulness and sadness. Carefully controlled testing with patient groups in cross-modal emotion tasks may thus lead to new insights, easily accessible and cost-effective therapies. In addition, these tests may provide valuable information on how emotions are processed when suffering from certain (affective) disorders. Cross-modal emotion studies with individuals afflicted by amusia, i.e., a condition that is characterized by an inability to enjoy music and recognize familiar tunes, may provide helpful insights into the nature and implications of this disorder, since the ability to recognize self-rated emotion in music is diminished, but still present in amusical people (Ayotte, Peretz, & Hyde, 2001). In addition to their theoretical relevance, the present findings may thus contribute to a better understanding and possibly even treatment of several psychiatric disorders (see also Jeong et al., 2011).

Conclusion

The experiments discussed in this review clearly demonstrate the emotional power of music, and may help us in understanding why music is so pervasive in our daily lives. Its ability to influence perception of emotion in others may be the reason why humans have been using music since ancient times in rituals meant to increase social bonding and to promote empathic responses from others. Investigating and understanding this capacity may prove valuable for the future, not just from a theoretical standpoint, but with numerous practical applications as well.

A more systematic approach that allows for a direct comparison between methods of music presentation should yield a greater understanding of the findings. The continued study of the effects of music on the perception of emotion should strive towards answering the important question of whether and how the findings from the laboratory are also applicable and relevant to real life situations.

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